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Introduction

Calorimetry or the measurement of heat transfer between animals and the environment has been conducted at MARC for several years. The primary objective of calorimetry has been the evaluation of maintenance energy requirements of animals. For cattle, maintenance requirements for either lactation or growth have been of interest.

Calorimetry can also provide information useful in evaluating heat dissipation by animals in various environments. Recent measurements were completed at MARC by a Swedish engineer to provide answers to a beef housing problem. Current information has proven to be inadequate for the design of beef housing ventilation systems, resulting in unacceptably high humidities in the buildings. Therefore, a study was designed to measure the heat and moisture production of cattle in response to air temperatures from 43 to 75°F.

Procedure

Four crossbred steers (Hereford x MARC III) weighing 575 to 862 lb were housed in environmental chambers for a 4-wk period to simulate housing conditions in a typical cold or temperate climate. The animals had free access to feed and water and were fed a silage based ration containing 59% dry matter, a metabolizable energy content of 1.37 MCal/lb, and 10.6% protein. The animals were adjusted to the ration and the facilities in a previous experiment. The animals were weighed at the beginning and the end of the experiment.

Two controlled-environment chambers with two stalls each were operated at four temperatures (43, 54, 64, and 75°F). One chamber was set at 75°F the first week and then lowered in weekly steps until it was 43°F the fourth week, while the second chamber was started at 43°F and then raised in the same manner to 75°F. The temperatures of the controlled environment test-chambers were changed in the first day of each measurement week. Body temperatures were recorded continuously, while heat production and heat dissipation measurements were made during the last two days of the week.

Total heat production of each animal was measured during a 23-hr period with a headbox which held both feed and water. There was one headbox in each chamber, so data were collected from two animals (one in each chamber) simultaneously. The equipment was moved from pen to pen when needed and removed when not in use.

Heat dissipation by sensible and latent (moisture evaporation) means was measured during three 3-hr periods per measurement day. Sensible heat loss (radiant and convective) could not be measured directly, but local values were calculated from spot measurements of animal and surroundings (wall and pen) surface temperatures and airflow. Radiant heat loss was calculated from surface temperatures measured with a calibrated infrared thermometer. Convective heat loss was calculated from air temperatures, animal surface temperatures, and air movement as measured around the animal. Convective heat loss was also dependent on the heat conductivity of the animal hide as affected by hair length and body fat content.

Latent heat loss included moisture loss from respiration and from the skin surface. Moisture loss from the skin surface was measured for about one hour on each of three sites on each animal during each heat dissipation measurement. Skin surface moisture loss was measured with a ventilated capsule designed to give the same heat and vapor diffusion resistance as the air film around the animal. The amount of water vapor collected by the capsule was determined from the standard corrected air flow through the capsule, and the calculated difference in moisture content between air entering and leaving the capsule.

The headbox provided the means to collect all respiration and head/neck skin moisture losses. Like the ventilated capsule, moisture loss was based on the standard corrected air flow through the headbox, and the calculated difference in moisture content between air entering and leaving the headbox.

Results

Time of day had minimal effect on heat loss which averaged .648, .717 and .711 Kcal/hr/lb for time periods of 04:30 to 7:30 a.m.; 10:30 a.m. to 1:30 p.m.; and 5:30 to 8:30 p.m., respectively. Average total heat loss affected by temperature and the partition of total heat loss into sensible, cutaneous, and respiratory heat loss are presented in Figure 1. Total heat loss increased by only 12% as temperatures dropped from 74 to 43°F. Latent heat loss, shown as respiratory and cutaneous heat loss, increased 2.5 fold from 43 to 75°F. Latent heat loss increased from 15% to 45% of the total heat loss from 43 to 75°F, and must increase to 100% of the total heat loss when air temperature equals or exceeds body temperature at 101.5°F. At that temperature, sensible heat loss would become negligible since there would be no temperature gradient between the animal and its environment. Over the temperature range studied here, nearly all of the increase in moisture loss resulted from increased cutaneous heat loss (increased from 9 to 32% of the total heat loss). Respiratory heat loss increased from 6 to 12% of the total heat loss.

It is apparent that moisture loads on a ventilation system become increasingly important as temperature increases. Although warm air physically holds a greater amount of moisture, and adding heat effectively removes moisture, these data show that the increased moisture production of beef animals could cause increased ventilation requirements without conserving animal heat loss. It is also evident that housing beef animals requires close attention to ventilation. Heat stress occurs when an animal is unable to dissipate its body heat through sensible and latent losses. The primary response of animals to heat stress, which may result from inadequate ventilation, is reduction in feed intake and subsequent growth. This is a primary factor in the problems which have limited the success of beef housing. Similar problems may occur whenever beef animals are held in close confinement, such as during transportation or marketing. It is vitally important that the producer, marketing manager, and the packer closely observe beef animals for signs of heat stress, even in relatively moderate or cool conditions. Skin wetness is an early sign that a beef animal

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is shifting its heat loss to latent means in order to offset heat stress. Increased activity associated with handling will increase the heat load and may have negative effects. Gentle handling, which is always important in moving animals, is even more critical when heat stress is evident.

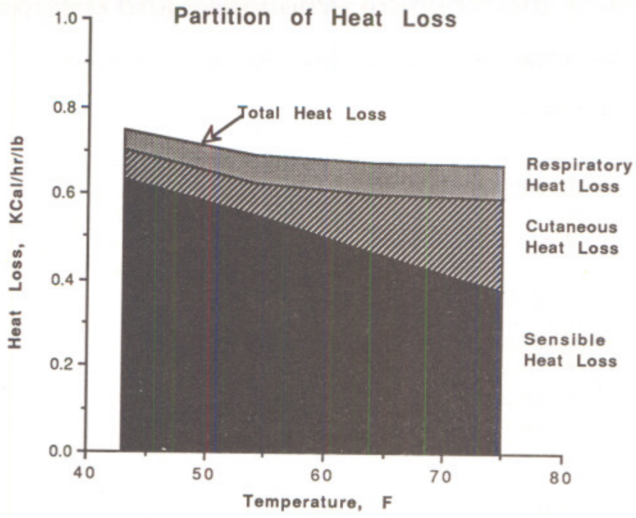

Figure 1 – Partitioned heat loss of crossbred steers averaging 720 lb and fed at room temperatures of 43°F to 75°F.